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AUTHOR Marsh, David D.; Odden, Allan R.
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ABSTRACT

Policymakers and analysts have a legitimate and intense interest in how state and federal policies can enhance the technical core of schooling and its impact on students. This study investigated: (1) how school districts and schools implemented the California mathematics and science curriculum frameworks; (2) the extent to which programs were actually used in classrooms; (3) the factors that explained successful implementation; and (4) the impact of the reform in classrooms. The case study methodology was used to provide comparable qualitative information about factors selected based on previous research. Study findings from a sample of 14 elementary schools are reported for three topics. The first is a set of site-specific factors critical to the implementation process. Factors examined included vision implementation, pressure/latitude/monitoring of the implementation process, and teacher effort to implement the change. The second topic considered is the role state policy initiatives had in enhancing/retarding the implementation process. Finally, the impact of the implemented programs on classrooms, teachers, and students is discussed. Based on the findings, four lessons about policy implementation are presented. (YP)

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STATE-INITIATED CURRICULUM REFORM IN ELEMENTARY SCHOOL MATHEMATICS AND SCIENCE PROGRAMS

David D. Marsh
Allan R. Odden

University of Southern California

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Policymakers and analysts have a legitimate and intense interest in how state and federal policies can enhance the technical core of schooling -- the curriculum and instructional program of the school - and its impact on students. Policy concerns about improving the technical core have gone through several stages since 1983. Initially, the concern was to do more of the traditional curriculum. When A Nation At Risk recommended that the American educational system could help citizens be more competitive in the international economy, it proposed higher standards and more years of traditional "academic solids" like mathematics, science, and English.

Subsequently, concern about the technical core shifted toward a curriculum that emphasized concepts rather than isolated facts, thinking and the creation of meaning rather than passive knowing, and problem-solving and expression so that the knowledge can be used to address meaningful problems. There has been a corresponding shift in instructional strategies away from just direct instruction on a narrow view of issues to a complex set of instructional strategies that promotes inquiry, active learning, group cooperation and social cohesion in a heterougous classroom.

Elsewhere, we have discussed the frequent finding that educational reforms were implemented quickly and with less resistence than would be predicted by a genre of policy implementation research (Odden & Marsh, 1989). The finding has been confirmed by other scholars such as Murphy (in press), Fuhrman, Clune and Elmore (1989) in a major multi-state study of reform implementaton, and by Firestone (1989).

Yet the early reforms are not like the current curriculum reforms, and the differences are sizeable. Whereas early reforms sought to stretch the existing system, recent curriculum reforms seek to revise the system and fundamentally change the classroom. The policy issues in this context are new and exciting, especially given the rather recent pro-active stance of state departments of education as curriculum reform leaders. The policy issues include whether the new approaches to curriculum can be implemented across district and whole schools rather than just in isolated classrooms,

whether this form of curriculum positively impacts on students, and whether state policies can meaningfully enhance implementation of this type of curriculum practice.

1. A FOCUS ON MATHEMATICS AND SCIENCE EDUCATION

There has been considerable interest in dramatically improving the teaching of mathematics and science in elementary schools. Impetus for such reforms comes from several related sources. Numerous reports demonstrate the strong link between mathematics and science and the job future of U.S. students (Johnston, 1987). Yet, by several standards, students have serious deficiencies in mathematics and science. When compared with students from other industrialized nations, our students fare very poorly in mathematics computation and mathematics reasoning (McKnight et al., 1987) and science (Jacobsen et al., 1986). Similarly, the National Assessment of Education Progress (NAEP) in mathematics "...clearly shows that although most students are reasonably proficient in computational skills the majority do not understand many basic concepts and are unable to apply the skills they have learned in even simple problem-solving situations" (Romberg, 1988, p. 5). The situation is equally serious in science where NAEP documents declines in science achievement (Hueftle et al., 1983) and lack of improvement in higher order reasoning about science (Applebee, Langer & Mullis, 1989).

Impetus for reform also derives from related concerns about equity of educational opportunity for students. Five out of six new entrants to the work force between now and the year 2010 will be either minorities, immigrants or women-- a disturbing problem when considered in light of a school system that Resnick and Resnick (1977) have characterized as a dual track system of "high literacy" and "low literacy" schools. Unfortunately, the "low literacy" schools tend disproportionally to serve ethnic minority students. Sex gender differences in mathematics and science performance also contribute to the nature of the problem facing our schools and society.

A host of national reform reports have provided extensive proposals for public school mathematics and science education reform. Building on early reports (especially A

Nation at Risk and Educating Americans for the 21st Century), extensive mathematics education reforms have been proposed including: What is Still Fundamental and What is Not ?(Conference Board of the Mathematical Sciences, 1983a), New Goals of Mathematical Sciences Education (Conference Board for the Mathematical Sciences, 1983b), and School Mathematics: Options for the 1990s (Romberg, 1984). Similarly, excellent science reform proposals include: What Science is Most Worth Knowing? (National Council on Science and Technology Education, 1987) and Educating Our Citizens: The Search for Excellence (Center for National Policy, 1983). The National Center for Improving Science Education provides an extensive analysis of these proposals and their contribution of current thinking about directions which should be taken (The NETWORK, 1987).

While important conceptual work remains to be done, these reports provide considerable consensus about the goals, content, and instructional strategies which should be incorporated into contemporary elementary school mathematics and science programs. For example, in mathematics education, the National Council of Teachers of Mathematics has provided a major synthesis of desired curriculum changes (NCTM, 1987; Romberg, 1988) and in science education, the National Science Teachers Association has provided a similar set of proposals which can be found in the Phase I report of Project 2061 (National Council on Science and Technology Education, 1987).

In addition to being comprehensive, these curriculum proposals have considerable research support. An excellent review of the teaching and learning of mathematics is provided by Romberg and Carpenter (1986) and a similar review of research on the teaching of natural sciences is provided by White and Tisher (1986). A more specific review of exemplary science programs for elementary schools points both to the "good news" and the "bad news" about elementary science programs (Bredderman, 1973). The good news is that when inquiry-oriented, activities-based elementary science programs are compared with traditional programs, students in the inquiry/activities programs are

significantly better at: 1) carrying out the process of science; 2) having more positive attitudes about taking more science; and 3) retaining more science content. The bad news is that many teachers, even those who participated in the NDEA Institutes of the 1960s, were unable to sustain classroom implementation of the inquiry-oriented programs. Only 20 to 25 percent of the teachers had successful implementation of these programs (Bredderman, 1973).

From a policy perspective, previous, post-Sputnik, National Science Foundation (NSF) supported efforts to improve science education were based on an effective curriculum orientation that simply was not implemented despite considerable federal government policy initiative. The national curriculum projects developed sophisticated but inflexible curriculum packages that often fit neither district curriculum priorities nor other aspects of the policy context such as testing or textbook adoption in the district or state. Moreover, teachers attending the summer institutes needed help in implementing the programs back at their schools. This help was frequently inadequate, or even nonexistent. Further, the implementation process ignored the organizational and systemic nature of the reform. Principals, district curriculum leaders and others failed to understand and support the reform sufficiently-- and the problem was both of will and capacity to do so. Sarason (1982) and Atkins & House (1981) provide an extensive analysis of the failure of these early curriculum reforms at the local school and district level.

Currently, state-stimulated reforms in mathematics and science offer considerable promise for improving on these old curriculum implementation problems. Recently, Smith (1988), Dean of the Stanford School of Education, argued extensively for the need to:

> "Focus change on a state by state basis. The state is the only place where the key policy levers all exist. States exercise or could exercise control over the pre-service training system, licensing, the curriculum framework, textbook adoptions and student testing. Each of these different aspects of the system will have to be harnessed together to provide the kind of major effort that is needed."

In this context, Smith made several more specific recommendations about the critical ingredients of state curriculum frameworks. He argued that the state framework should provide much of the reform details that will have to be undertaken locally. He believed that the framework should:

1. Represent the very best shot of thoughtful and experienced teachers, scientists, psychologists and curriculum specialists in the state;
2. Have content that is challenging, coherent and contains a logical and substantial core of knowledge and skills upon which to build; and
3. Provide guidance that is sufficiently complete and precise to build a solid structure on which to base an instructional and testing program, yet open enough to allow substantial creativity and ownership by teachers at the local school and system level.

For states that want a head start, he recommended two existing state science frameworks, including the California framework.

Like Smith, we see California's leadership in state- initiated curriculum reforms, specifically its curriculum frameworks, as being especially promising as a means to inform researchers, policymakers and practitioners about how the content, implementation and outcomes of today's curriculum reforms can best be carried out. We and others have conducted considerable research about state-initiated reforms that had a narrower focus (Anderson et al., 1987), about the implementation of state-initiated high school reform (Odden & Marsh, 1987; Odden & Marsh, 1988; Odden & Marsh, 1989; Marsh and Odden, forthcoming) and about state-initiated curriculum reform in middle schools (Marsh, Brown, Crocker & Lewis, 1989).

But the research/policy community has an inadequate research base about how state-initiated reform can work when the reform requires such a dramatic change in classroom practice as do California's current mathematics and science curriculum reforms. What is needed is a focused, indepth look at the role that progressive state policy initiatives

can play in the reform of elementary mathematics and science programs. This research is especially needed regarding districts and schools that serve diverse student populations and have been active in implementing quality programs. While the recent Educational Commission of the States study of the impact of state science initiatives suggests that states can be successful in changing district practice, it still does not answer the question of how to get real changes in classroom practice and equitable impact on students (Armstrong et al, 1988).

2. THE MATHEMATICS & SCIENCE CURRICULUM IMPLEMENTATION STUDY

This study explored the generic issue of whether state policies can enhance local curriculum reform. More specifically, the study was designed to determine: 1) how school districts and schools could successfully implement the California mathematics and science curriculum frameworks; 2) the extent to which such programs were actually used in classrooms; 3) the factors that explained successful implementation, including the role state policy levers played in the implementation process; and 4) the impact of the reform in classrooms. To accomplish these purposes, a coordinated set of intensive case studies were undertaken using a statewide sample.

Methodology

Sample. The study used a purposive sample featuring 14 elementary schools that had been especially active in implementing California's mathematics and science frameworks over the last several years. While the schools included the diversity of students found in the state, they were located in small-to-large size suburban districts and one big city district. The sample did not include either the largest or the very smallest districts because of the need to find patterns of implementation that could be useful to the typical California school district. Schools that had always had excellent programs were also excluded because of the need to study the improvement process itself.

Instrumentation. The study was based on indepth case studies featuring a methodology developed by Miles and Huberman (1984) and applied to the study of state-initiated reform by Odden and Marsh (1987, 1988). The case studies were designed to provide comparable information about: 1) the district and school mathematics and science program-- what it was, how it was developed and the role which state policy levers played in shaping it; 2) the implementation process for the mathematics and science programs including information about specified key factors, the way these factors fit together at each site, and site-specific circumstances that influenced the implementation process; and 3) the results of the implementation process including classroom practices, outcomes for students and changes in school organization or practice.

The case study methodology was selected to provide comparable qualitative information about predesignated factors drawn from previous research about mathematics/science programs or change process dynamics. At the same time, we anticipated factors that appeared to be important to reforms characterized as Wave III by Murphy (in press), or as second order reforms by Cuban (1984a). The structure of the case study data collection also allowed the research team to obtain information about site-specific unique factors and a global picture of how these factors fit together at a site.

In addition to the case study, several other instruments were used. A teacher questionnaire was used to determine the teacher's background (pre-service preparation and staff development experience in mathematics or science) as well as their orientation to the teaching of mathematics or science. To explore the extent and nature of classroom practice in mathematics and science, 8 teachers at each school were randomly selected (using stratified sampling), interviewed and observed. The teachers were asked to describe their mathematics (or science) curriculum and instructional practice over the current month and their plans for that subject area for the next semester. The teacher then was observed to provide a classroom practice context for understanding the interview. Information from the

interview and the observation was used by the data collector to complete a rating form derived from the content of the state curriculum framework in that subject area.

Data Collection. Data collection required approximately 11 days of effort per site and was conducted in two rounds where each round had a substantive focus and required qualitative and quantitative information collection . At each site, the data collection led to completion of a case study of approximately 80 single-spaced pages.

Cross-site data analysis. The cross-site analysis took place in several stages, including: 1) development of cross-site detailed descriptions; 2) development of high inference summary ratings for each variable; and 3) exploration of major relationships across policy initiatives, implementation process, program content and outcomes.

3. STUDY FINDINGS

Study findings are organized around three topics. The first is a set of site-specific factors critical to the implementation process. Five factors were examined because they captured the essence of the implementation process and offered the most policy-relevant insights about how it could be facilitated.

The second topic is the role of state policy initiatives in enhancing/retarding the implementation process. These policy initiatives include the obvious ones such as the state curriculum frameworks and the textbook adoption process, but also includes the role of other state policies that had considerable impact on the implementation process.

Finally, the impact of the programs on classrooms, teachers and students is discussed, even though this impact is only partially understood at this time. Impact is discussed in terms of tentative findings as well as emerging dilemmas for policymakers as they work to enhance the adoption and implementation of important new curriculum initiatives.

Critical Factors in the Implementation Process

While many implementation factors were examined in the larger study, the following discussion is focused on five especially important ones: 1) vision; 2) the

coordination and staging of the implementation; 3) assistance; 4) pressure/ latitude/monitoring of the implementation process; and 5) teacher effort to implement the change.

Vision. The role of vision was critically important to the success of the implementation process; but vision worked in new and surprising ways. Two general findings document the unique role of vision in these settings. First, both the mathematics and the science curriculum frameworks represented a major change for the schools and districts involved. In Huberman and Miles (1984) terms, the "scope of change" was extensive, or "ambitious" in McLaughlin's (Chapter 8) terms, as seen by both district and site leaders. More specifically, the new frameworks were seen as requiring:

1. Fundamental change at the classroom level.
2. Substantial change across many classrooms.
3. Change across the spectrum of classroom dimensions (including goals, content, materials, instructional strategies, learning strategies, grouping, space, time, evaluation of students).
4. For most teachers, a change in their conceptual "paradigm" about their curriculum and instruction.
5. Change nested in a new concept of schooling.
6. Restructuring of school leadership to support the classroom changes.
7. Change in the policy environment (district/state) to support the classroom changes.

The second general finding is the rapid and strong district adoption of the state-developed curriculum frameworks. By the end of the two-year adoption phase, all districts and respective schools had made a decision to adopt all aspects of each state curriculum framework. This pattern of early and rapid adoption fits with other recent findings of educational reform (Fuhrman, Clune & Elmore, Chapter 13; Murphy, in press; Firestone, 1989; Odden and Marsh, 1988). What is surprising in the current study is the early and

rapid adoption of the vision when the "innovation" is such a complex one as described above.

We found several critical reasons for quick adoption of the complex vision. First, the curriculum frameworks were seen as representing a "quality program", i.e., more than just a state mandate. In most of the districts, the curriculum frameworks were seen as representing the "best" of what was known about curriculum and instruction in these subject areas. Second, using the distinction provided by Peterson, Rabe and Wong (1986), the curriculum frameworks met a developmental need of districts and thus, as predicted, would be adopted more readily than if the policy initiatives were redistributive in orientation. Finally, the vision was adopted readily because the district leaders met the criteria of "active use" synthesized by Firestone (1989) in that these leaders (the dominant coalition described by Firestone) had a high propensity to action and interpreted the policy as meeting their interests.

Within this general set of findings about vision are some specific insights particular to the complex changes represented by the curriculum frameworks. Scholars of the local change process typically describe the process as including several phases: initiation and adoption, implementation, and institutionalization. To make sense of the vision found in these districts and schools, we found an additional phase to the local change process: an antecedent phase that is more than just antecedent conditions in the traditional sense. While the phase itself will be discussed later in the chapter, the vision developed in the antecedent phase played a critical role in the initiation and adoption phases as well.

In the antecedent phase, all schools were using "program pieces" such as Math Their Way, a popular and effective manipulatives based mathematics programs for primary grade students. These pieces were "plump" in that they: 1) were closely congruent to the new goals found in the mathematics and science curriculum frameworks; 2) included many dimensions of classroom practice such as integrating teaching strategies, instructional materials, and new content; and 3) allowed teachers to develop conceptual clarity about the

vision (see McLaughlin and Marsh, 1978). The vision during the antecedent phase was held primarily by teachers, principals and curriculum-focused district staff but usually not by district line administrators.

For the adoption phase, the typical metaphor would be "generic skeleton for the whole" rather than "plump pieces" as found in the antecedent phase. The skeletal/generic vision during the adoption phase was held by the district leaders and the formal district textbook adoption committee, and typically was synonymous with the framework itself and the particular textbook adopted by that district. Some districts also included a generic set of curriculum principles for that subject as part of the vision; but very few districts had an extensive and robust vision that was collectively held by the dominant coalition.

Implementation Coordination. During the antecedent phase, the locus of coordination was at the site rather than the district level. The focus was on the use of program pieces, and in 9 of the 14 cases, involved participation in regional networks of program users who were linked to national curriculum projects.

During the adoption phase, the locus of coordination shifted to the district level, and focused on: 1) reviewing the current district curriculum in either mathematics or science against the curriculum design found in the new state curriculum guides; and 2) selecting a new set of textbooks/instructional materials (from the state-approved list). Coordination during this phase was the most formal of the three phases: it included the broadest range of role groups, had the most formal organizational structure, and provided participants with training on the procedures to be followed as well as on the substantive issues involved. McMahon (1990) described these district coordination structures as follows:

> Every district had at least one district cross-role team whose membership was usually composed of someone from the central office, the principal or vice-principal, and teachers. Most members received some kind of formal-upfront training which resulted in being able to share their expertise and/or train others regarding the mathematics program implementation. The most frequent demands of the district

cross-role teams were selecting textbooks, providing training and inservices, and gaining an understanding of the adoption/alignment/implementation of the mathematics framework. (p. 161)

A similar pattern held for the science curriculum framework.

Analysis of the coordination structures during the adoption phase showed several patterns. First, using Firestone's concept of a "dominant coalition" (Firestone, 1989), the dominant coalition in this case was not primarily the superintendent and board members, but included two groups: 1) teachers and site administrators included on the district coordination structure primarily because of their substantive expertise and their previous experience in this curriculum area (usually developed in the antecedent phase); and 2) district staff who bridged the technical/bureaucratic boundary, i.e., who both understood the curriculum framework and had considerable influence with the superintendent and the board. Second, using McLaughlin and Marsh's (1978) concept of "vertical coordination" this district coordination structure clearly linked the school district vertically rather than horizontally.

Third, using McLaughlin's (Chapter 10) concepts of will and capacity, the district coordination structure during the adoption cycle served to consolidate the district will, or vision, rather than create it totally anew. District capacity for understanding and implementing the new curriculum frameworks often was built during the antecedent phase and was brought to the district coordination structure by teachers, site administrators and district leaders who really understood the curriculum. In an important sense, district capacity was developed for key district leaders prior to the adoption phase. Thus, the adoption and implementation phases were opportunities to expand rather than initiate this capacity.

In the district adoption process, one also can see the confluence of two cultures: the professional and the bureaucratic. As described above, the professional culture derived primarily from teachers, site administrators and some district leaders who understood the

curriculum as well as the district coordination structure. These people brought considerable knowledge built over at least several years -- knowledge often based on successful use of "plump" program pieces in their own classrooms, involvement in regional networks, and extensive inservice education. These people often had experience in providing help to others but had been blocked in getting other teachers to use the new programs. Their goal in district level participation was to build structures/policies that would foster wider implementation.

Members of the professional culture developed a new appreciation for the bureaucratic culture during the adoption phase. They recognized their need for what the bureaucratic culture offered: authority to demand attention and a signal that the new curriculum frameworks were important. The bureaucratic culture also was important because board approval of the new curriculum direction and the selected textbooks were required.

During the implementation phase, coordination structures shifted back primarily to the school level. This shift appeared to happen for several reasons. The multiplicity of curriculum frameworks (districts were engaged in implementing science and mathematics change with language arts and history change set for the next year) represented a complex set of changes that overwhelmed the district capacity for coordination in several respects. District curriculum leaders also had competing demands for their attention. The formal district staff was typically a very small group who had a new major curriculum framework to address each year. Despite their knowledge that implementation takes considerable time and energy, they had to shift their attention to the adoption phase for other frameworks, and to other curriculum and instructional responsibilities. Moreover, there was a tradition that the district textbook adoption committees focused primarily on the adoption rather than implementation issues. Finally, since the professional talent was primarily at the site level and since sites differed in many ways, it was understandable that implementation was structured at the site level.

In short, district leaders simply did not have the resources to coordinate implementation from the "top" and sites had to mount implementation activities to keep the curriculum change process moving. As discussed more below, the capacity developed during the antecedent stage was critical in sites being able to meet this implementation challenge.

Assistance. Four major trends characterized the assistance sites received to implement the curriculum frameworks. First, formal district capacity for providing assistance was clearly overwhelmed. Formal capacity included provision of district leadership, sufficient resources, and a comprehensive plan for coordinated implementation support services. Compared to the extensive adoption phase, the formal capacity during the implementation phase can be characterized as haphazard and opportunistic.

Second, despite this lack of formal implementation capacity, site staff found extremely creative ways to transform the skeleton vision into a living "operational curriculum". This transformation happened in several ways:

1. Continued Use of Program Pieces. Continued use and integration of "plump" program pieces begun during the antecedent phase. The typical school in the study had 4 to 7 plump pieces such as Math their Way, Family Math, Equals (from the Lawrence of Science) etc. These pieces were not dropped but instead were integrated into the new curriculum program as a specific way to operationalize the new curriculum framework.
2. Use of New Textbooks. Use of new instructional materials drew primarily on the new textbooks. Most districts adopted not the most innovative of the possible textbooks, but instead, typically selected texts that balanced the need to follow the new curriculum framework with what the district thought was feasible to implement given the many constraints found in the district. Consequently, the Opencourt series (judged to be the best aligned with most demanding view of the curriculum framework in mathematics)

was adopted in only two districts, and specifically not adopted for that reason in many of the others.

3. Use of New or Existing Instructional Materials. Many sites obtained considerable new instructional materials or adapted existing materials (often from the plump programs) to use in the new curriculum. As was found in the Study of Schooling (Klein, Tye and Wright, 1979), the availability of these materials strongly influenced teachers' willingness to try the new program.
4. Use of District Curriculum Guides and Model Curriculum. Most districts created summer institutes where lead teachers created curriculum units or examples which were shared with other teachers. These proved to be extremely helpful to teachers. Only one district created an extensive curriculum guide, however. Practicality was the dominant theme in the curriculum units; usable examples were a very persuasive means to help teachers implement the new curriculum.

These curriculum strategies did much to help teachers see how to transform the skeleton of the district adopted curriculum into a classroom reality.

Third, at the same time, extensive staff development was provided to teachers. The formal district staff development workshops often focused on upfront awareness training regarding aspects of the framework or on related instructional strategies such as cooperative learning. At many of the sites, the amount of additional inservices, workshops and assistance was often extensive. In her analysis of the implementation process at these sites, McMahon reports:

> Half of the districts provided extensive ongoing assistance for the mathematics program during the implementation phase (p. 162)...Ongoing assistance was less for science than it was for mathematics. Districts typically provided workshops but not as many as during the initial implementation phase. Teachers typically stated that science had gone to the "bottom of the stack" as district interest had turned to other subject matter areas. Half of the districts made little use of institutes and consultants

during the initial awareness, content and skill training in science. More resources had been used in mathematics (p. 165).

Finally, the creation of new assistance-related leadership roles was a typical strategy used at the sites. Most sites used mentor teachers to provide extensive help to other teachers through demonstration lessons and informal assistance. The mentor teaching program is a state-funded but locally-directed program that lets selected lead teachers help other teachers. Districts in the study redeployed these mentors to help with curriculum framework implementation. Some of the sites also organized teachers into learning teams facilitated by a lead teacher. In four districts, and especially in science, an especially active and energetic mentor teacher (or other site leader) became the district leader for continuing the implementation of that curriculum framework.

Monitoring/Latitude/Pressure. In mathematics, administrative support was "high" in nearly every district and appeared in the form of workshop, meetings and funds allocation for implementing the programs. Administrators typically took an active part in planning and arranging training for teachers. Monitoring the mathematics program took the form of daily or weekly walk-throughs or having teachers incorporate goals into their monthly or yearly plans. Pressure to implement the mathematics program came from the "bottom-up" as well as from the "top- down." In the "bottom-up" districts, pressure usually came from a core group of teachers, often those involved in the antecedent stage, who were especially skilled in mathematics education and who wanted to see the program in place. In some districts where there was "top-down" pressure, teachers complained of administrators who wanted to make too many changes too quickly. The extent of latitude varied throughout the districts, but the smaller ones had the most latitude. In these districts, the teachers were left essentially on their own to implement the mathematics program in their classrooms.

In science, the pattern was somewhat different. There was less administrative support for science as there was for mathematics. Some districts had no ongoing

assistance or program facilitators, and support for science had become symbolic. In other districts support was rated "high" and was evidenced by administrators who played a large part in obtaining funds and resources to keep their science programs in place. Administrative involvement was also less for science than it was for mathematics. Administrative involvement appeared in the form of visibility at workshops and presenting training sessions or modeling lessons for teacher.

Pressure to implement the science program was about equally distributed from "high" to "low." Districts rated "low" in pressure usually had little ongoing assistance or monitoring and staff development. Half of the districts were rated "high" in latitude and "low" in fidelity which resulted in many of the science programs being "watered down."

Teacher Effort. For mathematics, teachers at nearly all sites were rated "high" in teacher effort. Most teachers had received a sufficient amount of information about the mathematics framework and had experience enough administrative support to "buy into" the program. Extent of teacher effort varied more for science than it did for mathematics. In some districts, few teachers seemed to care about science and were feeling overwhelmed with other subjects.

Role of State Policy Initiatives

We found that many state policy initiatives were related to the successful use of the state curriculum frameworks. These initiatives included:

1. The Curriculum Frameworks Themselves. The frameworks were written by a committee of school, district, university and state Department of Education staff and consisted of several documents outlining the overall philosophy of the curriculum, the key themes and content to be addressed and an overview of the instructional process needed to give vitality to the curriculum.
2. The Seven Year Textbook Adoption Cycle. This cycle is designed to help districts carry out three phases of curriculum adoption and implementation. The first two phases are designed to take a total of two years. Phase I consists of a comparison of

district curriculum to the new curriculum guide (a mandate) and an assessment of current strengths and weaknesses. Phase II consists of comprehensive planning and the selection/adoption of instructional materials.

In the words of the memo from the State Department of Education, during Phase III, "all schools in the district begin implementing the revised curriculum. School with additional program resources use their (School Improvement Program councils) and other committees to initiate their regular planning process in the development of curriculum and instructional improvement strategies." (Smith, 1987).

3. The Approved List of Textbooks and Instructional Materials. The state curriculum frameworks served as the intellectual guide for the state committee process of selecting approved textbooks and instructional materials. For both mathematics and science, this state-level selection process was controversial in nature resulting in modifications of the approved textbooks/materials themselves. For example, in science, the treatment of evolution and human sexuality was revised. In mathematics, textbook companies were forced to revise their materials to include more inquiry oriented lessons and examples.

4. The State Testing Program (CAP) Including the Public Report Card For Each School. The California Assessment Program (CAP) uses matrix sampling to test student at grades 3, 6, 8 and 12, in order to portray school- and district-level achievement trends. For the third and sixth grades, the test include mathematics, but not science, at the present time. Moreover, the 8th and 12th grade tests have recently been revised to be aligned more closely with the new curriculum frameworks. The elementary school level testing had not undergone this revision; consequently, the new curriculum directions reflected in the curriculum frameworks was not aligned very well with the elementary school CAP program. Given the public nature of the reporting of scores, schools raised considerable concern about this problem which is in the process of being addressed.

5. School Improvement Program. A comprehensive reform process which provides a planning process and funding directly to local schools. Almost all of the elementary schools in the state have had this program for over 10 years. A recent feature of the SIP program is the Program Quality Review (PQR) that includes a self-study and subsequent external review by peers from the geographic region. These reviews are based on Quality Indicators drawn directly from the state curriculum frameworks. The Quality Indicators portray what a classroom should look like if it is in keeping with the curriculum directions found in the state curriculum frameworks.
6. Mentor Teachers. A state-funded program that allows district-level selection of up to 5% of teachers who are paid a stipend to assist other teachers or develop innovative curriculum within broad state guidelines. Various districts have deployed their mentors in dramatically different ways: some emphasizing individual mentor-defined projects while other districts have deployed the mentors more "strategically" to help all teachers implement district priority programs, such as new curriculum frameworks.
7. Various funding for staff development. In some cases, the state has funded recognized curriculum leadership centers such as the Lawrence of Science (on the UC Berkeley campus) to offer curriculum programs and staff development to a network of schools in that region of the state. In other cases, the staff development funding goes directly to the district and/or school.

Several observations are relevant about the state policy initiatives and their influence on the local adoption/ implementation process. First, at the state level the policies were designed to "fit" together and coordinate the policy arena in which local implementation takes place. Moreover, the state had the resources and clout to alter the nature of instructional materials available to local schools. Without this clout, the policy arena might not have been as supportive of local program change.

Second, for several reasons, the curriculum frameworks had considerable influence on the local adoption process. There were several reasons for this extensive influence:

1. They fit with national views of "good" science and mathematics as reflected in national reform reports and supported by a strong tradition of visible research. In many of the districts, a few leaders knew of this national pattern, partly through the regional networks which were so important during the antecedent phase.
2. They fit with local priorities. Like Firestone (1989) and others, district leaders in our study reported that they were already working in the directions proposed by the curriculum frameworks.
3. The frameworks were credible for other reasons. For example, recognized teacher, district and county leaders in that subject area helped write the frameworks. Moreover, the frameworks (mathematics more than science) were seen as user-friendly, i.e, accessible, understandable, and feasible.
4. The frameworks were generic enough to allow for flexible adaption by districts yet focused enough on essential and new concepts to represent a powerful new view of curriculum in that subject area.
5. The state had a tradition of activist activity in education and conducted quality dissemination of the frameworks through state and regional conferences.

At the same time, the comprehensive planning/implementation process proposed in the 7 year curriculum cycle memo was not as effective. During adoption, districts conducted much simpler, and cruder comparisons of current curriculum with the new state curriculum frameworks than was proposed: the adopted curriculum was a skeleton rather than a comprehensive design. During implementation, planning was informal, fragmented and opportunistic rather than extensive and formal as proposed in the state memo.. In short, the state curriculum frameworks overloaded local capacity, especially in the area of comprehensive planning, but also in many other ways.

Third, some state policies not directly linked to the curriculum frameworks were critically important to the success of the implementation process. Mentor teachers were a crucial resource for staff development, curriculum development and revision; at the same

time, they allowed the informal lead teachers of the antecedent phase to achieve more formal authority, access to resources, and attention. Another critical state policy initiative was the PQR process of the SIP program. This process provided the obvious pressure directly on local sites but also served an important educative function as to what the curriculum framework would look like in practice. This education came not from district bureaucrats, but instead, from professional colleagues.

Finally, the state policy initiatives influenced all phases of the local change process, and at the appropriate organizational level (site vs. district). During the antecedent phase, staff development in the regional networks and the use of SIP funds to implement the plump program pieces was critical to the development of site and district capacity for implementing the curriculum frameworks. Other state policy initiatives, especially the curriculum cycle, the frameworks themselves, and the textbook adoption process strongly influenced the creation of new district visions of mathematics and science and the coalescing of the dominant coalition to promote it in the adoption phase. Many of the state policy initiatives helped during the implementation phase, but in a rather haphazard and uncoordinated way.

The frameworks themselves helped in many ways. They served as an opportunity for a new content vision, provided an outline that could be expanded, gave access to the best of "good practice," confirmed that certain ideas and people were "on the right track," consolidated and integrated previous plump pieces, and became a source of momentum, a flywheel that continued the momentum which otherwise would have been dissipated. Perhaps most importantly, the frameworks served an educative function: they helped local practitioners focus on what to learn.

Impact of the Implementation Effort

For several reasons, the study could not provide an extensive analysis of the impact of these policy initiatives on classroom practice. It was too early in the implementation process to collect definitive impact data and an extensive collection of such data was

beyond the scope of our available resources. However, it was possible to document several significant trends.

First, both the mathematics and science curricula had been extensively implemented in classrooms. Our study involved classroom observation and indepth interviewing of randomly-selected teachers at all sites. In most cases, teachers were using most of the appropriate curriculum themes found in the state frameworks.

Second, mathematics curriculum implementation clearly exceeded science curriculum implementation. Moreover, in seven sites, there was clear indication that use of the new science program had receded or been discontinued. This lack of institutionalization happened for several reasons. At the district level, one important pattern was the less active nature of district involvement in the implementation process itself. Compared to district involvement in the mathematics framework, the implementation process for the science framework had less district support, less monitoring and pressure and more latitude given to local sites. In short, the science curriculum was more frequently discontinued because it was ignored as the district moved on to mathematics. As a result, science enjoyed less support and assistance from the time of early implementation.

In turn, this district pattern also can be seen as portraying less district will and less capacity for implementing the science framework. Since the CAP test did not assess the science learning in students but did assess other curricular areas, district leaders understandably focused on these other areas. This shift in focus was accentuated by the inadequate staffing and resources at the district level for curriculum and instructional leadership in general; when demand exceeded supply, mathematics demand held over science demand. Moreover, the capacity for science leadership was always weaker than it was for mathematics.

At the site level, signals from the district that other curricular areas were important was a reality driven home be the more compelling insight that elementary teachers were facing a new curricular reform every year. The year after the mathematics framework was

implemented, teachers were to undertake a major revamping of the English/language arts curriculum towards a whole language approach to reading/writing/literature. Teachers were understandably focused on that more central and critical reform--a reform made doubly significant given the large number of Limited-English-Proficient students in the California schools these days. Further, the new history curriculum framework also had been released so teachers knew yet another curriculum area was stated for major overhaul in the short term.

Moreover, the science curriculum involved use of numerous instructional materials that either were lost over time or were designed to be used only once. Districts typically couldn't afford to replace these materials, which were the heart of an inquiry-oriented science program.

Policy Implications

This study provides four lessons about policy implementation of the more recent waves of reform. First, an antecedent phase was very important for building local capacity for implementing the complex new reforms. This antecedent phase preceded the formal adoption phase and allowed for the development of "plump pieces" of the new programs, development of lead teachers who were very competent in the new program, and a network linking teacher leaders to regional technical assistance networks. For reform that requires extensive change at the classroom level, some capacity development must precede formal adoption.

The second lesson centers on teacher professionalism. Beyond willingness to experiment and develop a common technical language, teacher professionalism in this reform process focused primarily on developing expertise in the new innovation. Development of teacher expertise often came from other teachers within regional networks of assistance. As McLaughlin (Chapter 8) has pointed out, these professional networks were very powerful and were the source of reform-focused assistance.

Conversely, teacher professionalism as "control" was not a critical factor in the reform process. It was not the parity arrangements of the School Improvement Process that led to teacher professionalism; instead, it was professionalism based on expertise that was critical.

The third lesson relates to the nature of the implementation process in terms of its being "top-down" versus "bottom-up" in nature. In implementing recent waves of reform, a new pattern of "top-down" and "bottom-up" linkage was seen. During the antecedent phase, efforts were primarily "bottom-up" in that teachers and schools, rather than district leadership, were often the initiators of the linkages to regional networks of assistance and program development. During the formal adoption phase, the reform was coordinated at the district level (the "top-down" dimension) but often utilized the vast talents of the lead teachers (the "bottom-up" dimension). During this phase, these lead teachers represented technical expertise rather than merely the "workers" who know the classroom and its realities best.

However, during implementation, the process again became primarily site-based rather than district led. With multiple major reforms being undertaken, the district leadership was overwhelmed in several ways: a) the leadership had to coordinate the adoption of programs in other curricular areas, and b) it lacked the expertise, resources, and time to facilitate the details of the implementation process. Consequently, intensive, ad hoc, site-based efforts were the key to successful implementation of these reforms.

The final lesson is that policy initiatives were very important to each phase of reform implementation. During the antecedent phase, the regional networks were often state-funded efforts. These networks included the program development and staff development efforts, such as were provided by the Lawrence Hall of Science on the UC Berkeley campus, as well as regional awareness conferences funded by the State Department of Education.

During the adoption phase, the state curriculum frameworks were extremely important in setting the vision for the reform and educating local leaders about this vision. District leaders were required to compare their current district curriculum with the new framework as well as undertake an extensive process for selecting appropriate instructional materials from a list of state-approved alternatives. Since the state was providing the funding for the purchase of these materials, it was able to command the attention of district leaders to this process. The local process of defining curriculum directions and selecting related instructional materials was also influenced by several state-initiated accountability mechanisms such as the state testing program and the accountability report card required of all districts.

Moreover, during the adoption as well as the implementation phases, the state mentor teacher program often provided the specification and formalization of teacher leadership roles. Mentors were also given the incentives and rewards that increased the attractiveness of this role. Many other state initiatives provided resources and a planning process for focusing local assistance efforts on these important reforms.

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